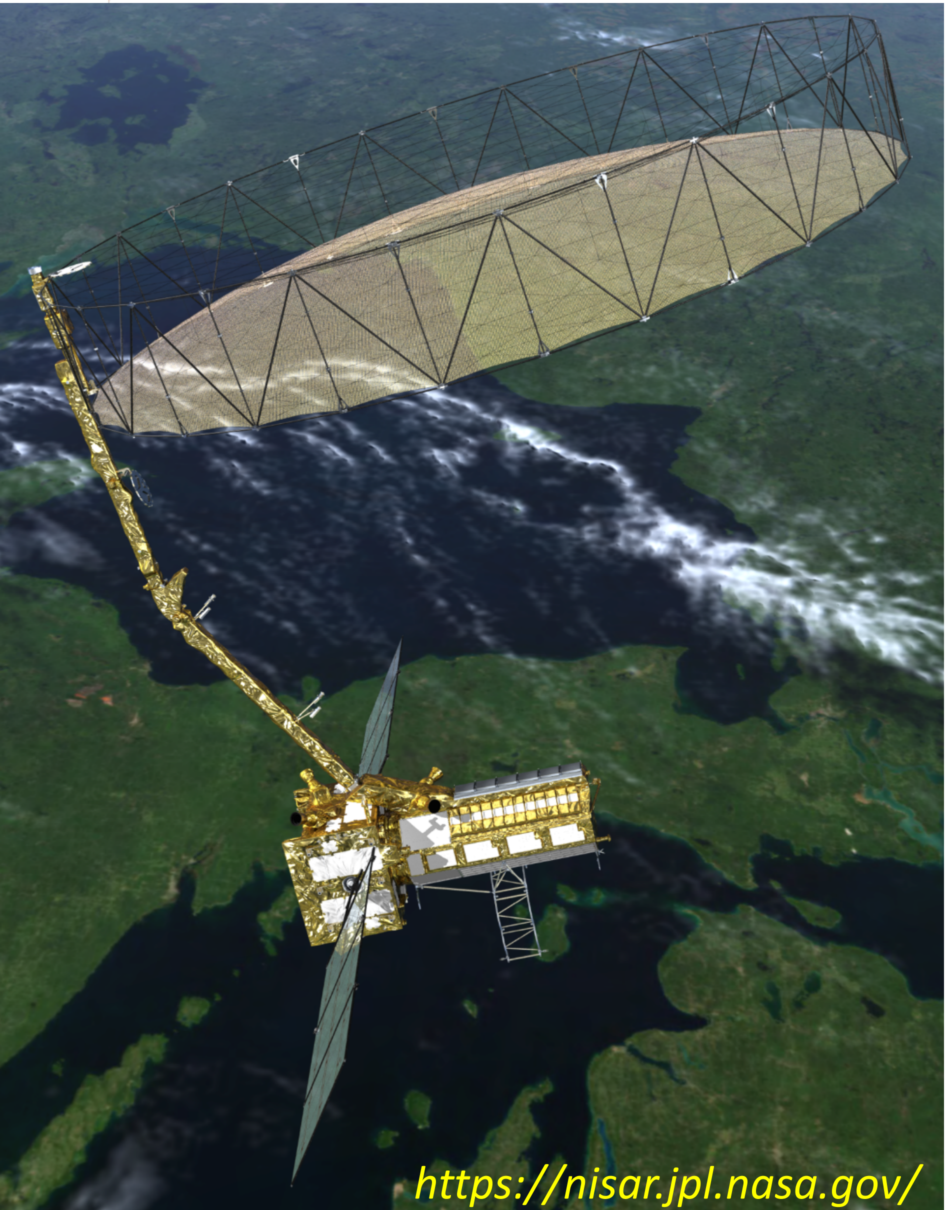
Indian Space Research Organisation

Jet Propulsion Laboratory
California Institute of Technology



NISAR
NASA - ISRO SAR Mission

Uniquely Capturing the Earth in Motion

NASA-ISRO SAR Mission Status

Franz Meyer
NISAR Science Team Member
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NISAR Project Scientist
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NISAR Project Manager

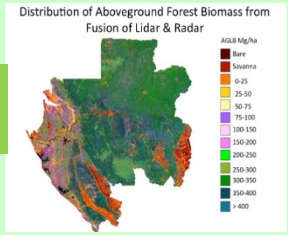
October 2019

NISAR Mission Overview

NISAR
NASA - ISRO SAR Mission

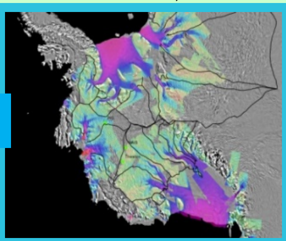
Mission Science

Ecosystem Structure



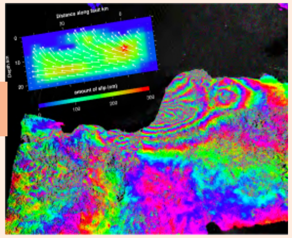
Biomass disturbance,
Effects of changing climate on habitats and CO_2,

Cryosphere



Ice velocity, thickness
Response of ice sheets to climate change & sea level rise

Solid Earth



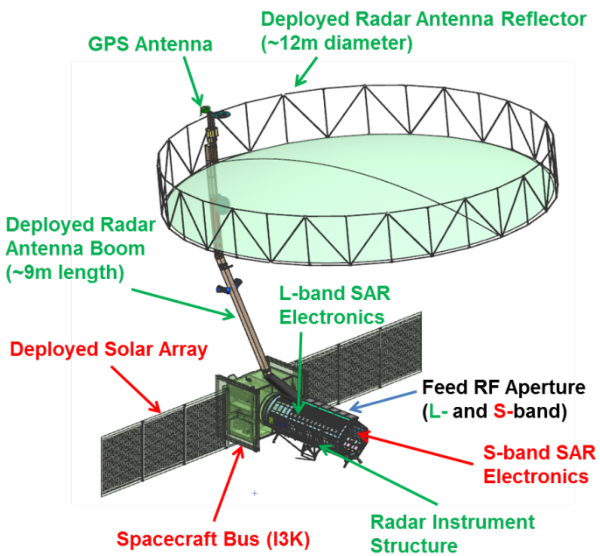
Surface Deformation
Geo-Hazards
Water Resource Management

- Directed mission under NASA's Earth Science Division
- Cat 2 project (NPR 7120.5E) & payload risk class C (NPR 8705.4)
- International partner: Indian Space Research Organization (ISRO)
- Launch no earlier than January 30, 2022 for left-look only mission
- Dual frequency L- and S-band Synthetic Aperture Radar (SAR)
- Baseline orbit: 747km altitude circular, 98 degrees inclination, sun-synchronous, dawn-dusk (6 AM – 6 PM), 12-day repeat
- Repeat orbit within +/- 250m
- Spacecraft: ISRO I3K
- Launch vehicle: ISRO Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II (4-m fairing)
- 3 years NASA science operations (5 years consumables)
- 5 years ISRO S-band SAR and spacecraft operations
- All science data (L- and S-band) will be made available free and open, consistent with NASA Earth Science open data policy.

NASA-ISRO Observatory Work Share

NISAR — NASA - ISRO SAR Mission

On-Orbit Configuration



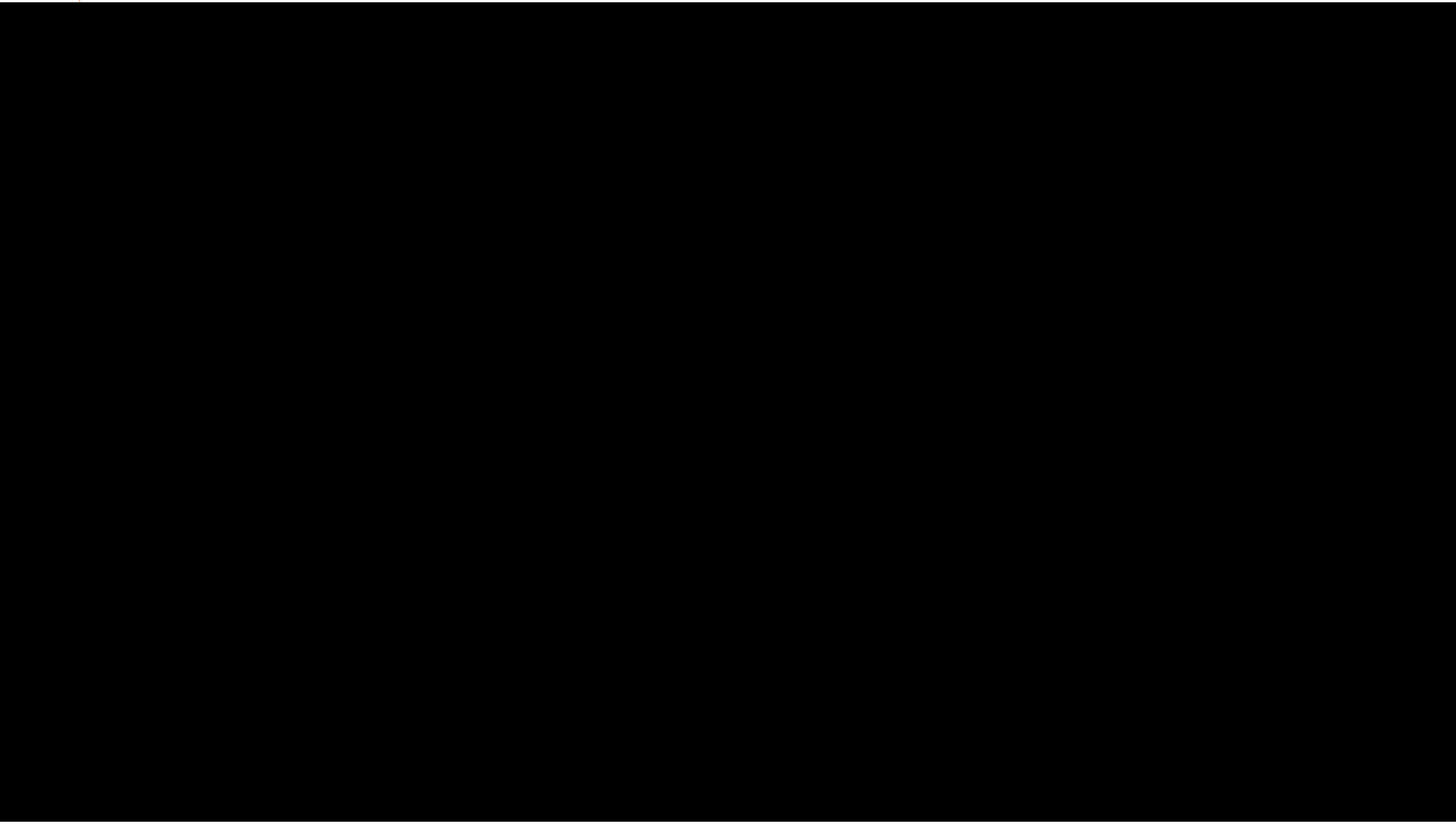
- Spacecraft Bus System (ISRO URSC)
  - I3K heritage bus with modifications
- Radar Payload System
  - L-band SAR aka DSI (NASA)
  - S-band SAR (ISRO SAC)
- Engineering Payload System (NASA)
  - Payload Communication Subsystem (PCS)
    - Ka-band high rate transmitter
  - GPS Payload (GPSP)
  - Solid State Recorder (SSR)
  - Payload Data Subsystem (PDS)
  - Power Distribution Unit (PDU)
  - Pyro Firing Assembly (PFA)
- Launch Vehicle (ISRO VSSC)
  - Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II (4-meter fairing)

ISRO
NASA

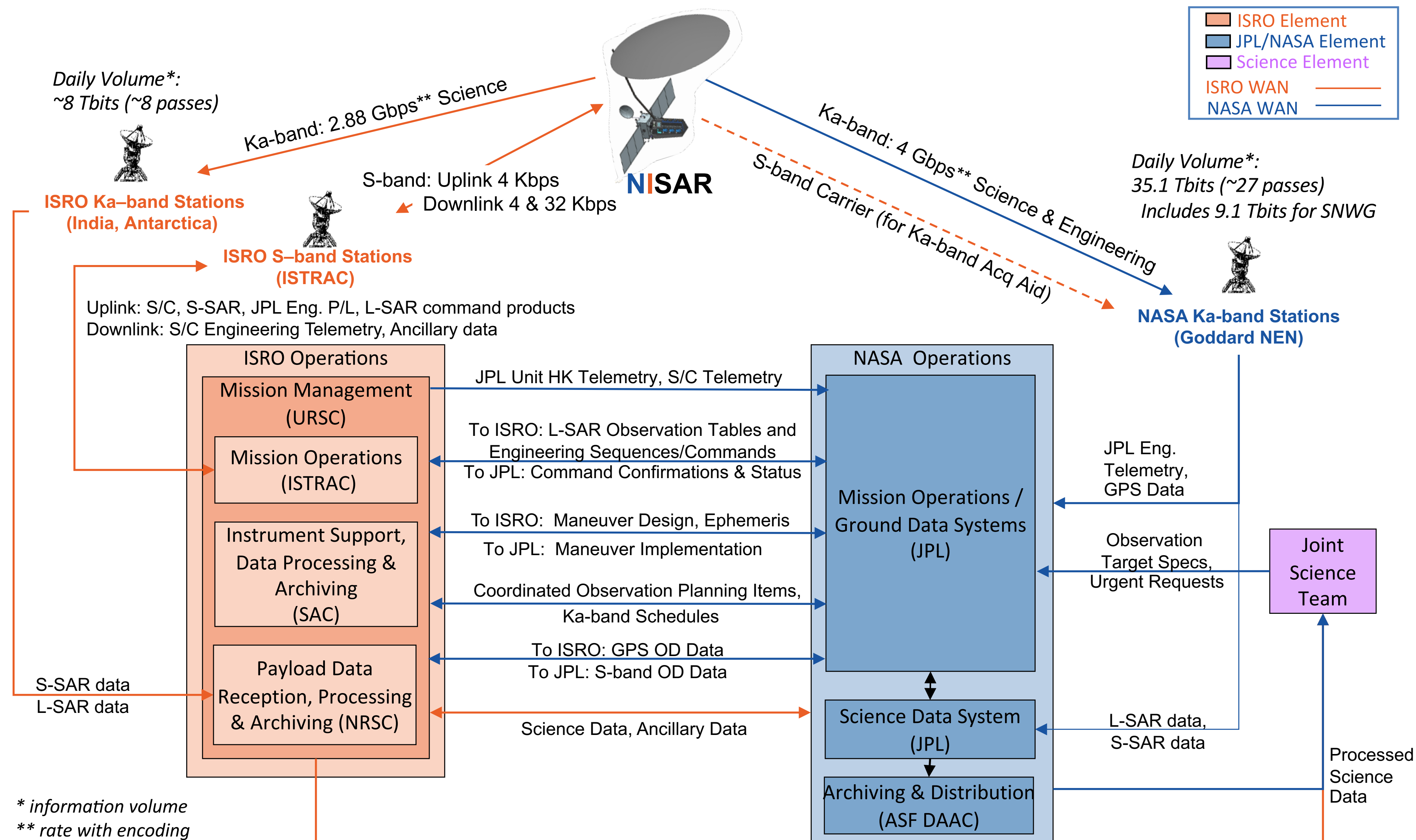
DSI = Dual-band SAR Instrument

URSC: U. R. Rao Satellite Centre
SAC: Space Applications Centre
VSSC: Vikram Sarabhai Space Centre

Mission Animation



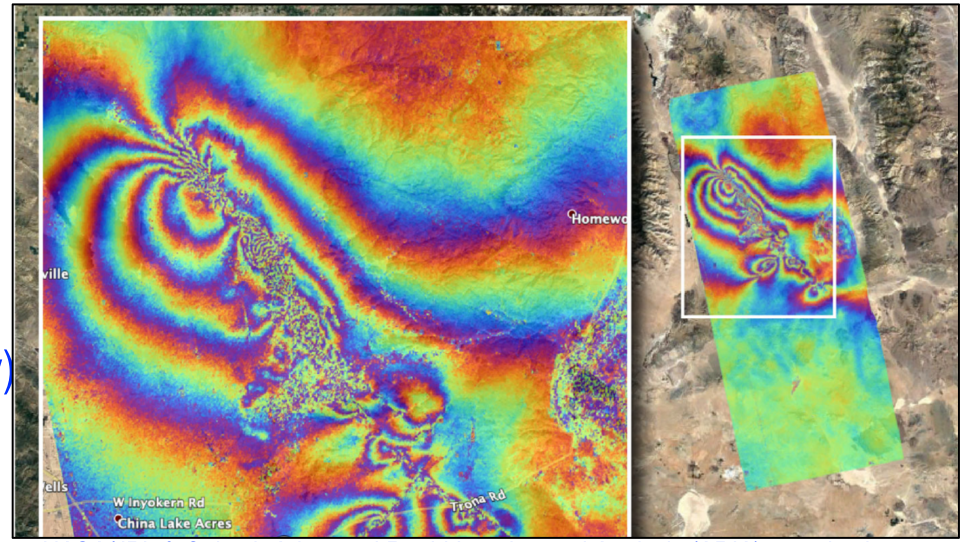
Mission System Architecture



Rev: 8/14/19

Unique Science & Technology

- Simultaneous wide-swath, fine resolution, multipolarization radar allowing complete global coverage of land & ice-covered surfaces
- Dual frequency (L/S- band) free-flying radar
- High rate Ka-band mission data return (35 Tb/day)
- First time use of commercial cloud-based ground processing and distribution systems
- Received funding augmentation for add'l data return to support other agencies' needs
- First-of-a-kind radar technologies
    - First digital beam forming radar in space
    - First Phased-Array Feed Reflector system in space
    - Largest known SAR aperture in history (~100 sq m)



NASA/JPL & Caltech Advanced Rapid Imaging and Analysis (ARIA) co-seismic Interferometric Synthetic Aperture Radar (InSAR) surface displacement map from recent earthquakes (JAXA ALOS-2 data from April 8 and July 8, 2019). With NISAR, these will be produced weekly around the globe for earthquakes, floods, eruptions…

First flight Ka-band Modulator in initial power on and functional testing

NISAR System I&T Is Underway

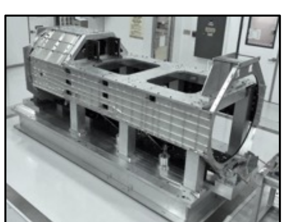
Pre-SIT

Subsystem I&T

3/1/17 – 3/1/19

- L4 and L5 S/S verification
- Box-level environmental
- EM Testbed activities
- RIS assembly
- Various locations



SIT-1

L-SAR I&T

3/7/19 – 1/8/20

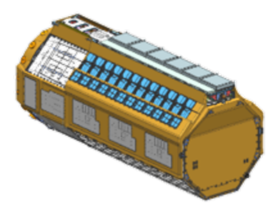
- L-SAR integration to RIS
- L-SAR functional testing
- L-SAR Performance TVAC test (no FRAP)
- Building 306 HB

SIT-2

Dual SAR I&T

1/9/20 – 7/22/20

- S-SAR/clamshell integration
- L-SAR and S-SAR compatibility testing, radiating tests
- Bldg 306 HB, Antenna Range



DTM: Mech I&T

7/1/19 – 4/1/20

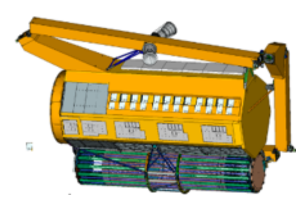
- RAR, RAB, RAS integration to RIS
- Deployment testing
- Environmental testing
- Building 306 HB, Bldg 144 and 150

SIT-3

Payload Sys I&T

7/23/20 – 2/8/21

- EP and hosted HW integration
- EMI/EMC test
- RAB and RAR integration
- Stow, deploy, first motion
- Mass Properties
- Acoustic and vibe
- Non-radiating thermal balance TVAC
- Bldg 306 HB, Bldg 144 and 150

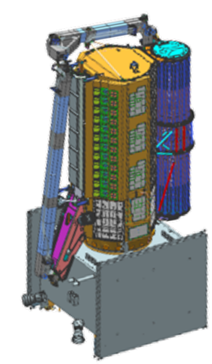


SIT-4 / AIT

Observatory I&T

3/18/21 – 10/27/21

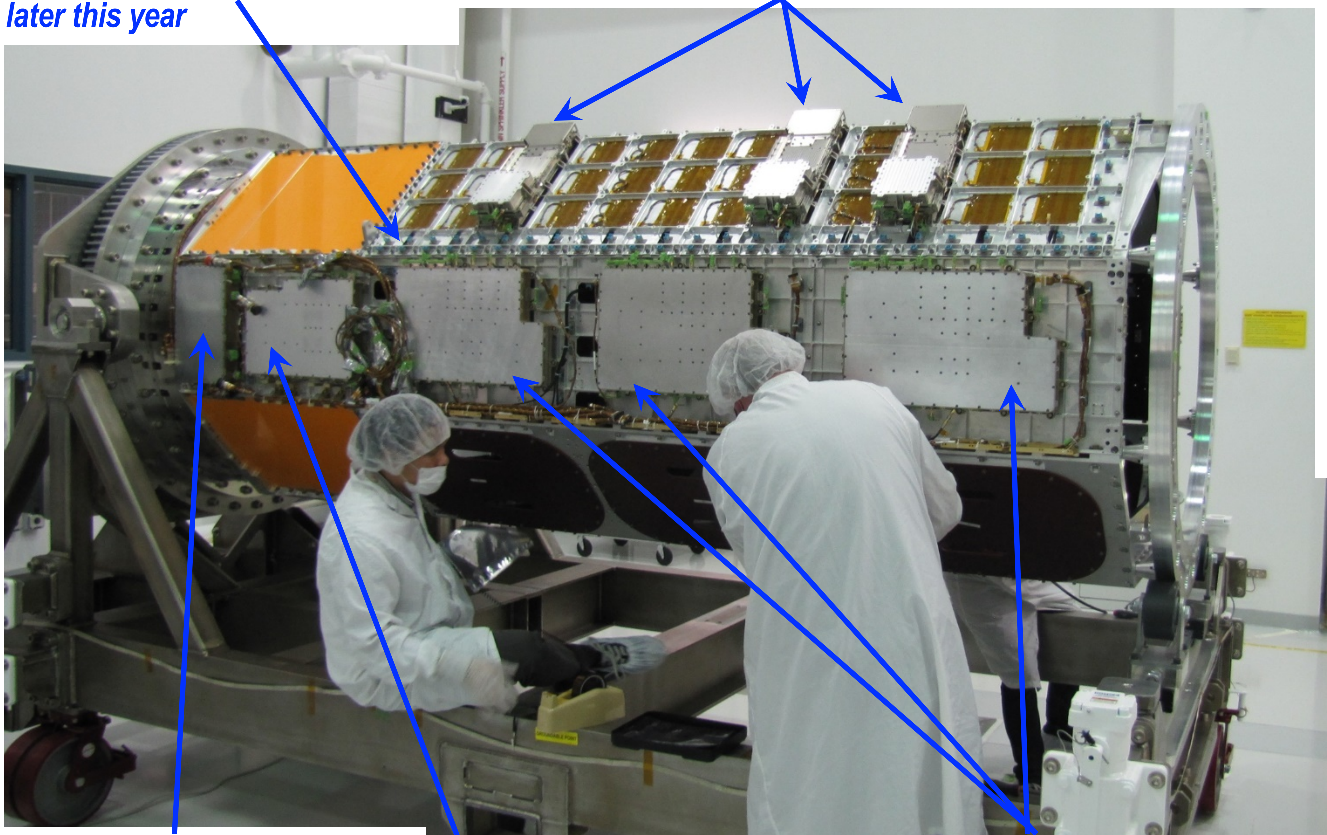
- RP and S/C mech integration
- RP/SC electrical integration and spacecraft power test
- Observatory EMI/EMC, Dynamics and TVAC



L-SAR Integration Progressing Well – System-Level Testing (V-pol) Has Started

Radar Instrument Structure on rotisserie fixture that will be used for thermal vacuum test later this year

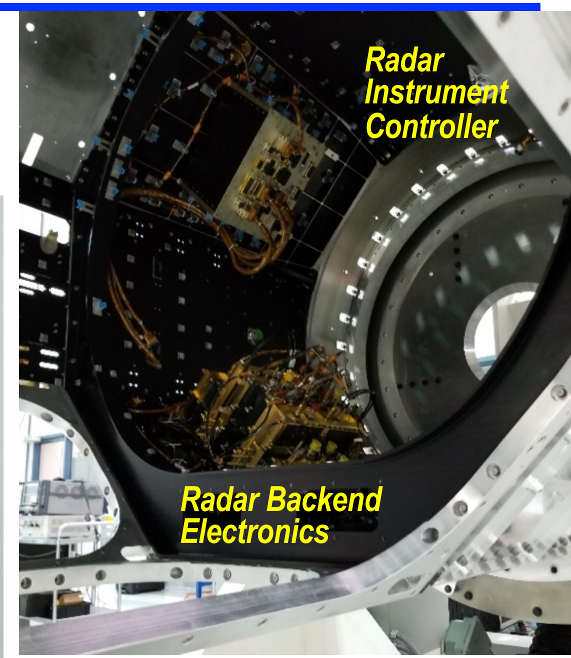
First 3 (of 24) flight transmit/ receive modules installed



Digital Signal Processors Power Converter Unit

Second Stage Processor

Quad-First Stage Processors



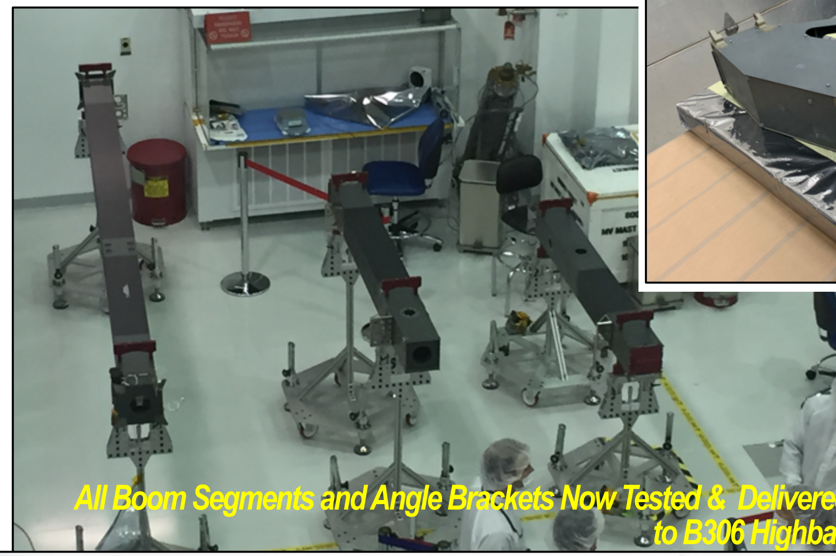
Interior View of Radar Instrument Structure

"Hey! It's (almost) a radar!"

Dynamic Test Model (DTM) Integration Has Started

The DTM Program Protoflight Tests the Structural Elements - including the Reflector and Boom - and occurs in parallel with L-SAR and S-SAR I&T

DTM/Flight Spare Radar Instrument Structure (RIS) delivered to DTM I&T



All Boom Segments and Angle Brackets Now Tested & Delivered to B306 Highbay

Reflector Cradle in Assembly at Astro

First flight Radar Antenna Support (or Structure) as completed manufacturing at Maxar (formerly SSL)

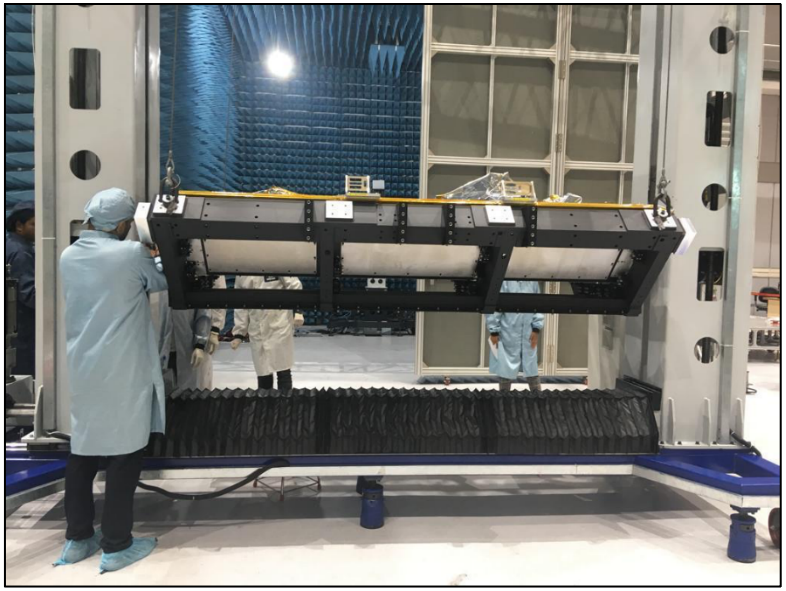
Reflector Truss Assembly has Begun!

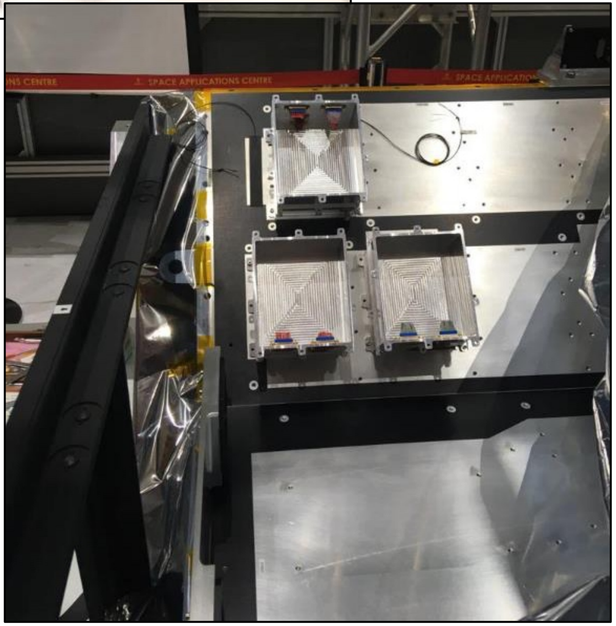
NG Astro completed assembly of 12mm diameter reflector truss; will begin reflector front & rear net/mesh integration in late August

ISRO S-SAR Integration is Beginning

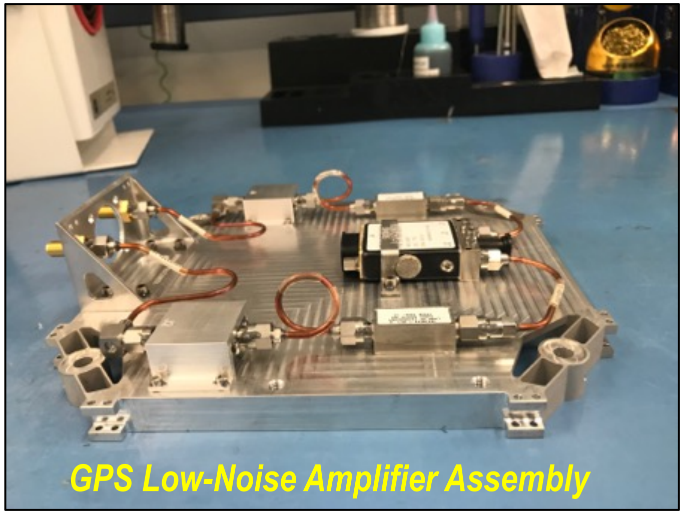
RIS/Clamshell unpacking and handover to ISRO-SACfor S-SAR I&T (June)

ISRO/SAC moved Clamshell onto turnover fixture and began installing 'dummy' electronics boxes to facilitate S-SAR harness installation. Electronics installation is planned to start this month





Engineering Payload Elements Progress



GPS Low-Noise Amplifier Assembly

Flight Solid State Recorder Has Been Delivered to JPL

First Flight Ka-band Modulator Integrated and in Test

Science/Mission System Status

- L1 and L2 science product algorithms are maturing well
- Cloud-based Science Data System has been tested end-to-end with Sentinel-1 archive at ASF
  - Preparing to produce sample data products for science team evaluation from UAVSAR and Sentinel-1
- NASA Near Earth Network developments are on track
- Initial release of Ground Data System has been deployed to I&T activities
- JPL Flight operations team is staffed up and working commissioning and other post-launch plans for CDR
- Mission design and interface documentation is mature for Mission System CDR, passed September 2019

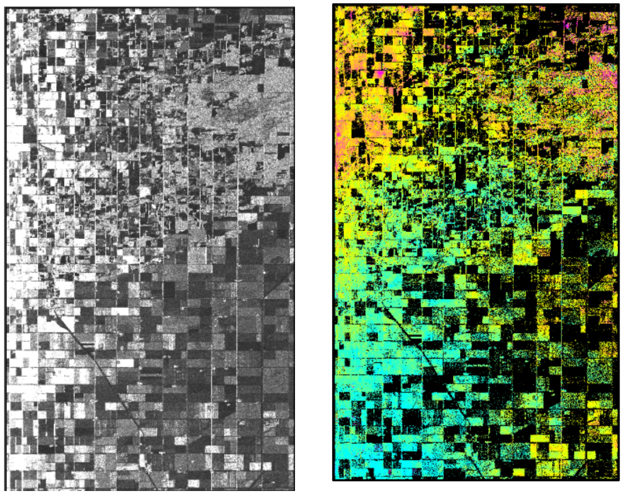
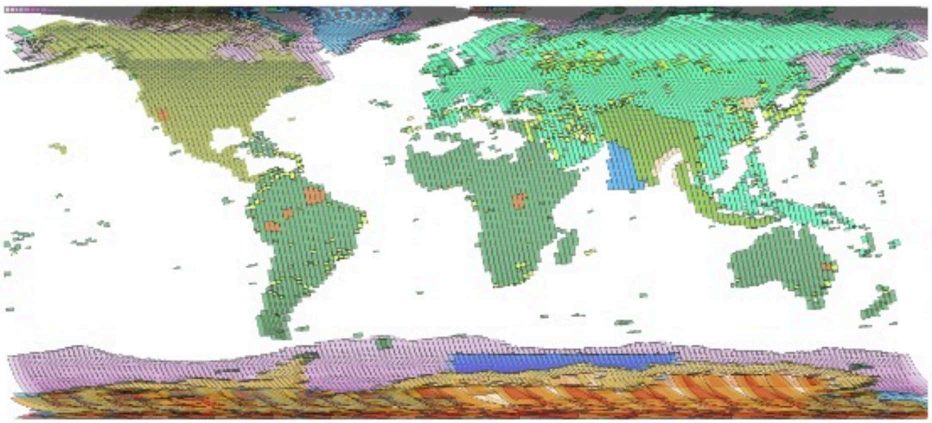


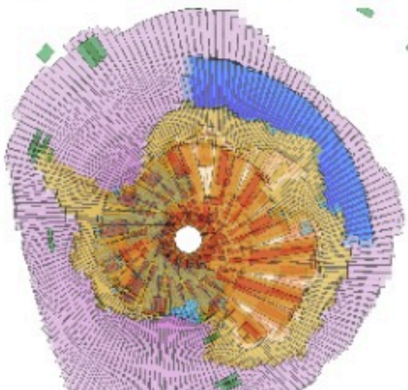
Image amplitude (left) and InSAR Phase (right) generated from NISAR sample SLC products.

NEN AS4 Antenna at ViaSat Facility

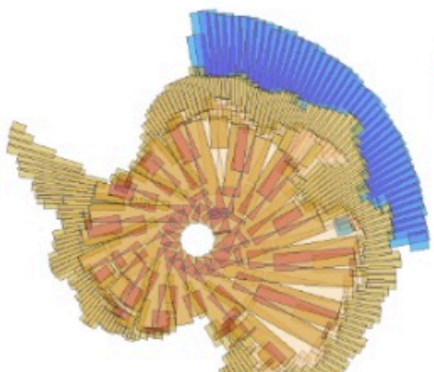
Cycle 000

Current Planned Coverage

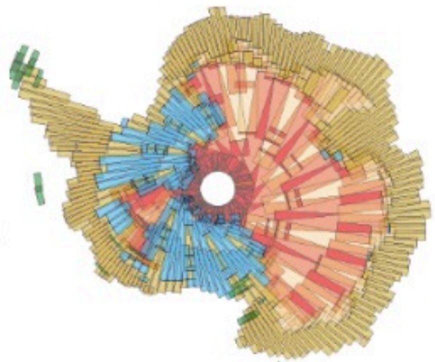




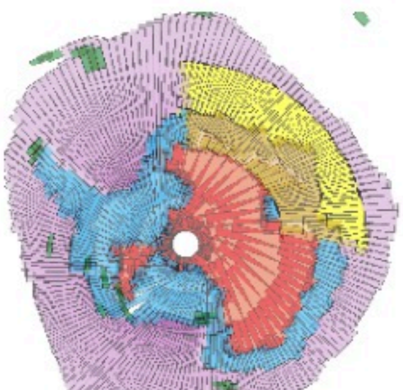
Ascending composite



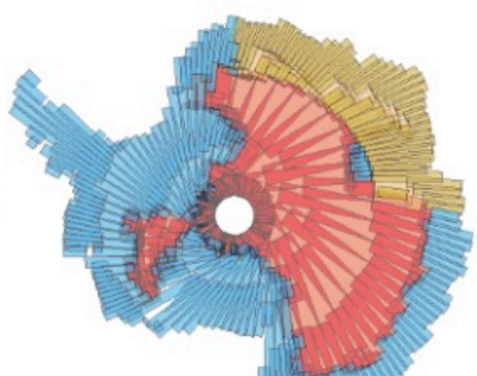
Ascending S-SAR



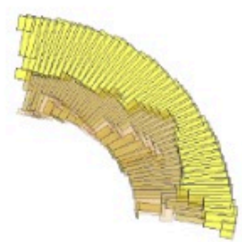
Ascending L-SAR



Descending composite



Descending L-SAR



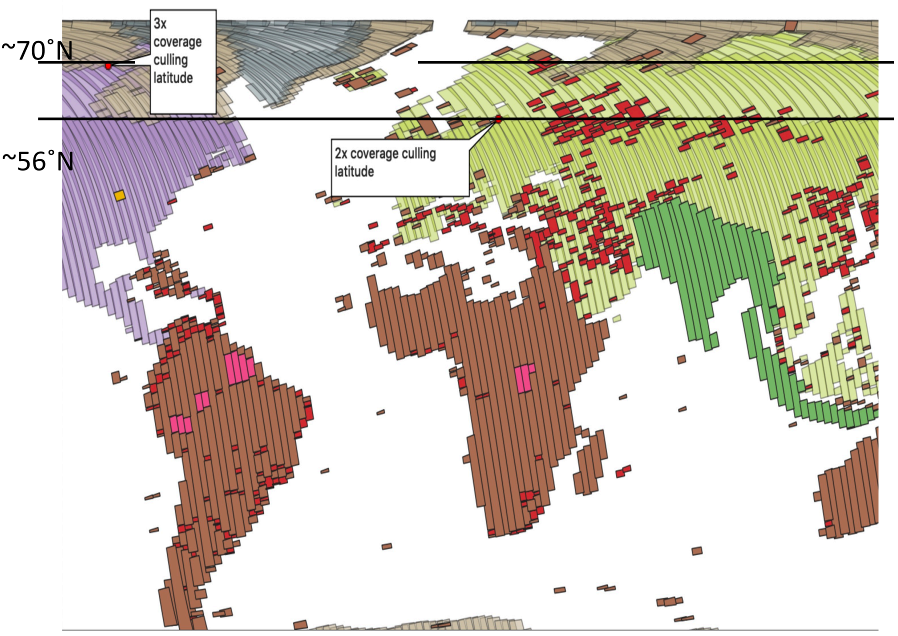
Descending S-SAR

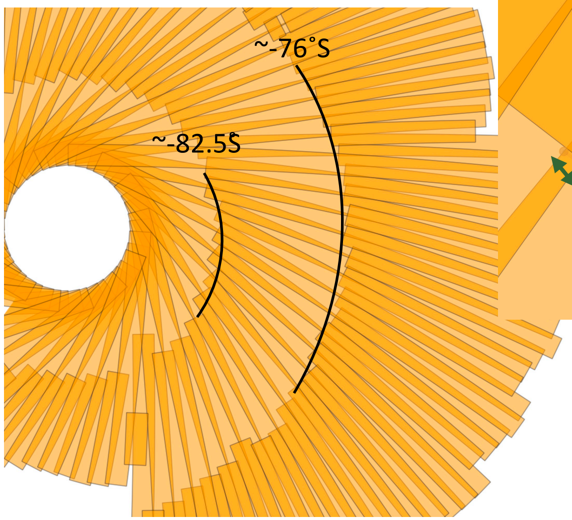
N.America is covered ascending and descending (drk-yellow) Plan 337: L-SAR QQP 40+5

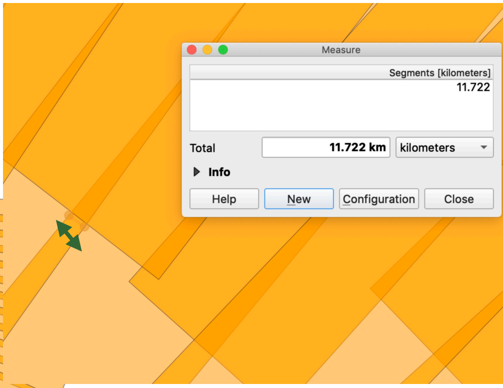
- Non-EU urban areas are observed (lt-yellow) at L-SAR 40+5 DP
- Current plans have significant work done in Antarctica to collect an ISRO S-SAR mosaic every cycle and to lower L-SAR Data Volume using lower-rate full-swath modes as compared to previous plans (e.g. 325)
- Plan to update plan every 6 months

Culling Strategy

- Near the equator, we get complete coverage of the earth each cycle by observing every opportunity
- Near the poles, NISARs ground tracks and swaths converge – requiring only ½, or a third, or fewer observations per opportunity for full coverage per cycle
- Overlap of adjacent swaths at culling latitudes has been increased from prior iterations of Reference Observation Plan







Antarctic
half-swath culling

NISAR Top Challenges

- Schedule
  - S-SAR delivery from ISRO/SAC appears very likely to be delayed
  - Unknown impact on launch date.
- NISAR may be the most highly integrated joint internationally operated mission NASA has yet implemented;
  - Details of joint operations being worked out

NISAR Mission Capabilities Preserved Through Development

- With all electronics subsystems built and currently in integration, the system is on track for fully planned functionality
- Since initial requirements reviews, capabilities of the system have been stable
  - Science and Imaging performance requirements are mostly unchanged
  - Waveforms have been degraded in average power slightly to meet FAA low interference thresholds
  - Hardware as tested meets subsystem requirements
- Thanks to DLR research into SweepSAR performance, it is clear that quad-pol *cannot* satisfy complete global performance requirements every 12-day cycle.
  - Gaps in swath due to sweepSAR are large for quad-pol
  - Dithering at high quad-pol PRFs leads to unacceptably high ambiguities
  - Quad-pol observations over India are baselined, but every other cycle imaging is sufficient
  - Rest of the world are primarily Dual-pol observations